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BREAKDOWN OF EXPENDITURES IN CONSTRUCTION OF HYDROELECTRIC POWER PLANTS IN USSR

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In connection with calculating conversion coefficients from 1945 to 1949 prices, Gidroenergoproyekt determined the composition of expenditures from the construction estimates of five hydroelectric power plant construction projects: Kama, Minchegaur, Verkhotur'ye, Dzaudzhikau, and Khram.

A breakdown of the estimated cost by item was carried out according to specified items of expenditure established in the accounts of the TsSU (Central Statistics Administration) of the USSR. In the case of the Kama and Mingechaur GES, the breakdown was considerably more detailed. The main results of this analysis of expenditures are given in the appended tables.

Table 1 (appended) shows the principal composition of expenditures for the five hydroelectric power plants and the proportional distribution of the total direct expenditures for construction and assembly work. A comparison of these figures shows that there is a fairly stable ratio for the amounts spent for individual expenditure items except for the following characteristic deviations:

In the case of the Mingechaur GES, the cost of materials is lower and the cost of machine operation higher, because of the high cost of an earth dam, built by hydromechanization methods. In the Verkhotur'ye GES, and especially in the Dzaudzhikau GES, expenditures for wages are considerably higher because of the relatively small amount of mechanization on these projects. In the case of the Khram GES, the cost of machine operation should be considered with "other direct costs" which, according to the computations of this GES, include the expenditures for mechanical transport. In the case of the other power plants, this expenditure was considered under the heading "Machine Operation."

A further breakdown of the cost of construction and assembly work was made in the case of the Kama and Mingechaur GES (see Table 3).

In analyzing the figures given for two of the largest hydrotechnical structures of the postwar Five-Year Plan, special notice should be taken of certain cost ratios which contradict the generally accepted ideas concerning the

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composition of construction expenditures. This applies most of all to the relatively small proportion of the allocated cost of materials to the total sum of direct expenses, i.e., less than half in the case of the Kama GES and less than a third in the case of the Mingechaur GES. This low cost of materials makes it possible to lower construction costs for hydroelectric power plants, since the allocated cost of materials determined on the basis of technical norms and established state prices is itself an item of cost which is almost impossible to reduce in a given project by rationalization in construction.

The cost of transporting materials, including loading, unloading, and packaging, and expenditures for processing and storage, are 39 percent of the allocated cost of materials for the Kama GES, and 63 percent for the Mingechaur GES, which is more removed from the industrial centers. These expenditures are one of the largest components in the total cost of construction and assembly work: 16.8 percent of the total direct expenditures for the Kama GES and 19 percent for the Mingechaur GES.

These expenditures, as opposed to the allocated cost of materials, can be reduced through such measures as selecting the most economical methods for the external transport of materials, reducing the distances of carrying locally manufactured materials, eliminating superfluous transfer of loads, and improving the operational indexes of transport work.

Machine operation costs 50 percent more than wages paid manual laborers at the Kama GES and almost 100 percent more at the Mingechaur GES. In this connection, within the limits of the total cost of operation, the working force of machine and vehicle operators is comparatively small (2.7 - 3.8 percent). Expenditures for power resources are about 11 percent of the total direct costs for construction and assembly work, and so-called fixed costs (large-scale assembly expenditures and amortization deductions of the hydromechanical equipment) amount to 9.1 percent for the Kama GES and 17.1 percent for the Mingechaur GES.

The fixed costs include the cost of transporting machinery, its assembly, dismantling, amortization, and repair, also the cost of lubricants and abrasives and the upkeep of the machine shop or other related organizations (offices, departments) in charge of the machine operation.

In the case of the more mechanized Mingechaur GES, these fixed costs for machinery exceed the total wages of manual workers and comprise over half the cost of materials according to allocated prices. From these comparisons, one can see the enormous effect of correct machine operation on the cost of constructing a hydroelectric power plant, from the moment of transporting and assembling the machinery on the construction site until it is finally dismantled and removed.

The general composition of capital outlays for hydroelectric power plants, based on the same two GES, is shown in Table 3. In this comparison, attention is drawn to the proportionately low cost of construction and assembly work (less than 50 percent of the total), for the Kama GES. This is mainly explained by the high cost of clearing the water reservoir basin (23.9 percent of the total cost of the GES), and also by some increase in the proportionate cost of equipment, i.e., 38 percent of the cost of construction and assembly work as against 27 percent for the Mingechaur GES.

A large unassigned expenditure in the cost of the power plants under consideration is the expense connected with clearing and preparing the water reservoir basin. This expenditure is taken from the general and financial estimates, not according to technical estimates.

The figures in Table 3 show the necessity for applying greater care and thoroughness to the problem of expenditures for reservoir development in the planning and estimating costs for hydroelectric power plants.

In addition to its other work, Gidroenergoproyekt also compiled a list of basic construction materials per million rubles for construction and and assembly work, in prices and norms of 1945. Such data of materials were compared for the following seven hydroelectric power plants on a basis of estimated costs: Kama, Mingechaur, V. Svir, Verkhotur'ye. Khram, Kransnopolyansk, and Dzaudzhikau. For comparison, the data concerning expenditures for basic construction materials by Dneprostroy were reduced to 1945 prices.

Table 4 shows the weighted average of costs for basic construction materials per million rubles, the minimum and maximum costs of materials, and the figures for DneproGES.

Indexes for the Kama GES show that the highest expenditures are for metal, stone, brick, and lime, but at the same time it has the lowest figure for expenditure on cement. At the opposite end of the scale is the Verkhotur'ye GES which has the highest figure for cement expenditure and the lowest figure for metal. The V. Svir GES has the highest expenditures for wood, sand, and gravel.

The DneproGES expenditure indexes for basic materials are much higher than the average of the seven power plants under construction as regards timber, cement, and rails, and considerably lower in other materials, especially metal.

Proportional distribution of the cost of basic materials in these plants is given in Table 5. The cost of the principal construction materials of hydrotechnical construction (metal, cement, wood) and the most important materials for civilian and auxiliary construction (brick, wood, lime) comprises about 15 - 17 percent of the total construction costs in both of the largest power plants under construction.

The relatively small cost of basic construction materials is espcially remarkable when compared with the cost of machine operation at the Mingechaur GES (16 percent of the total cost of the GES, i. e., almost as much as the cost of the principal materials, including the cost of transporting them to the construction site).

For the Kama GES, the principal materials for constructing its own hydro unit (not including cost of the reservoir basin) cost only 50 percent more than machine operation and, at the same time, cost 50 percent less than the amount spent in clearing the reservoir basin.

From the standpoint of practical planning, the given figures show that when planning hydroelectric power plants, problems of organization and mechanization of construction are as important as the designs of the main hydrotechnical structures.

/Appended tables follow./

Table 1

Power Plant	Wages	Material f.o.f. site Warehouse	Machine Operation	Other Direct Costs	Total
Kama	16.1	59.9	22.5	1.5	100
Mingechaur	16.2	49.5	31.5	2.8	100
Khram	15.3	63.0	13.2	8.5	100
Verkhotur'ye	20.5	61.9	15.0	2.6	100
Dzaudzhikau	24.5	65.8	7.0	2.7	100
Weighted average	16.2	55.4	25.9	2.5	100

Table 2

Items of Estimated Cost	Hydroelectric Power Plants	
	Kama	Mingechaur
Basic Wages for		
Construction	13.7	14.7
Assembly	2.4	1.5
Total	16.1	16.2
Materials		
Allocated costs	43.1	30.4
Rail transportation	5.5	9.2
Local transportation	5.7	4.3
Loading and unloading	2.9	3.9
Procurement and packaging costs	1.4	0.8
Processing and warehouse expenses	1.3	0.9
Total	59.9	49.5
Machine Operation		
Fixed expenses	9.1	17.1
Wages	2.7	3.8
Electric power	8.8	6.8
Coal and wood	0.3	0.4
Liquid fuel	1.5	3.2
Water and air	0.1	0.2
Total	22.5	31.5
Amortization of railroad lines	1.2	2.7
Other expenses	0.3	0.1
Total	1.5	2.8
Grand total	100.0	100.0

Table 3

Items of Estimated Cost	Kama GES		Mingechaur GES	
	Percentage of Total General Estimate	Excluding Expenditure For Water Reservoir	Percentage of Total General Estimate	Excluding Expenditure For Water Reservoir
Construction and assembly	46.4	61.0	65.0	68.5
Equipment				
Basic	9.8	12.9	10.9	12.5
Construction	6.7	8.8	5.1	4.4
Transportation and warehouse expenses	1.1	1.4	1.1	1.1
Other expenses				
Cleaning and preparing reservoir basin	23.9	--	5.1	--
Planning and research work	5.4	7.1	7.0	6.3
Other expenses	1.9	2.5	1.0	2.2
Unforeseen work	4.8	6.3	4.8	5.0
Total	100.0	100.0	100.0	100.0

Table 4

Materials	Weighted Average of Material Consumption per million rubles	Maximum Consumption of Materials	Minimum Consumption of Materials	DneproGES Indexes
Timber in the round, cu m	1,020	1,525	679	1,738
Cement, t	382	657	338	476
Ferrous metals (equipment, metal structures, sheet piles, tubes, forgings), t	171	226	46	79
Rails and clamps, t	10.6	32.5	0	14.6
Sand, cu m	1,241	1,637	1,070	683
Gravel and shingles, cu m	1,733	2,352	1,413	1,550
Stone, cu m	770	1,109	520	663
Bricks, thousands	117	154	32	48
Lime	32	39	19	20

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Table 5

Materials	Kama GES		Mingechaur GES	
	Percent of Construction and Assembly Cost	Percent of Total Overall Estimates	Percent of Construction and Assembly Cost	Percent of Total Overall Estimates
Lumber	3.06	1.42	2.55	1.66
Cement	3.38	1.57	2.86	1.86
Ferrous metals	12.11	5.63	6.11	3.97
Rails	0.24	0.11	0.39	0.25
Sand	0.67	0.31	0.20	0.25
Gravel	1.31	0.61	1.42	0.92
Stone	0.56	0.26	0.65	0.42
Bricks	2.43	1.13	1.44	0.94
Lime	0.24	0.11	0.57	0.37
Total	24.0	11.15	16.30	10.59
Grand total, including transport	33.36	15.50	26.56	17.26

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